A New Total Wrist Fusion Locking Plate for Patients with Small Hands or with Failed Partial Wrist Fusion: Preliminary Experience

Juan González del Pino, MD, PhD[1]

[1] Division of Hand Surgery, Department of Orthopaedic Surgery, Santa Cristina University Hospital, Madrid, Spain

J Wrist Surg 2013;3:148–153.

Address for correspondence Juan González del Pino, MD, PhD, Servicio de Cirugía Ortopédica y Traumatología. Hospital Universitario Santa Cristina, C/ Maestro Vives 2. 28009, Madrid, Spain (e-mail: juangpino@telefonica.net).

Abstract

The author has designed a custom-made titanium plate for total wrist fusion for small-handed persons or patients with failed partial wrist fusions. From May 2011 to April 2013, this plate was used on 13 wrists, 5 of them with a minimum follow-up of 1 year. This implant is downsized compared with the standard wrist fusion plate: lower in profile, shorter in length, and narrower than the standard one. It is fixed to the radius by means of 2.7-mm screws and to the capitate and third metacarpal with 2.4-mm screws. In the curved plate all the screws are locked to the plate with a predetermined coaxial angle. The plate has a curvature to fit the dorsum of the carpus; it is 10° dorsally extended and has undercuts on the contact areas at the radius and third metacarpal dorsal surface. The indication for this implant is a short-statured patient for whom the standard plate is too large and bulky; a failed partial wrist fusion or proximal row carpectomy, for which a shorter plate is needed because only one articulation should be fused (midcarpal or radiocapitate joint); or both. The five wrists (two primary fusions and three failed radioscapholunate [RSL] fusions) healed between 11 and 14 weeks. No plate loosening was observed, and none of the patients felt painful prominence to the distal end of the plate on the dorsum of the hand.

Keywords
- wrist
- total wrist fusion
- partial wrist fusion
- locking plate

Despite the fact that nowadays partial wrist fusion (PWF) and proximal row carpectomy (PRC) are frequently used to maintain wrist motion, total wrist fusion (TWF) still remains an useful procedure to manage certain wrist conditions, such as trauma, advanced Kienböck disease, and degenerative or inflammatory arthritis.[1–3] Cavaliere and Chung[4] recently demonstrated that TWF provided better outcomes when compared with total wrist arthroplasty in rheumatoid patients. Since the mid-1990s a specific TWF plate is widely used to manage all the aforementioned wrist problems.[2,5] To avoid screw toggling and plate loosening, and subsequently to increase the stability of the construct, in 2008 the manufacturers of that plate (Synthes, Oberdorf, Switzerland) introduced locking technology in the standard wrist fusion plate. However, although the set includes three different plates (one straight and two curved, with different curvatures), only one size is available. As a result, small wrists must be fused using a larger implant than can fit them, and therefore a larger, unnecessary approach is needed. In those cases the plate can be even wider than the third metacarpal or the radius where they are placed (►**Fig. 1a, b**). In certain wrists, such as those of slender women or those affected by rheumatoid arthritis, that plate is too bulky beneath the extensor tendons and provokes also a painful prominence at its distal end.

To address this issue, mainly in women affected by inflammatory diseases, many of them with massive carpal collapse, the author used a low-profile, locking mandible plate (Compact 2.4 mm Unilock Reconstruction MF System, Synthes) in 42 TWFs with excellent results.[6] The author also used that plate for small-handed persons and for those with a failed

DOI http://dx.doi.org/10.1055/s-0033-1351657.
ISSN 2163-3916.

Fig. 1a,b (**a**) TWF after a failed PRC in a slim young man. Both width and length of the plate are excessive related to the patient's wrist size. (**b**) TWF for advanced rheumatoid disease in a small-handed woman. Both plates' ends are wider than the recipient bones' width.

PRC. Rheumatoid patients, who frequently are slender and have dorsal tenosynovitis and skin atrophy, were successfully addressed with this low-profile mandible plate.

The aim of this article is to communicate the author's design and his preliminary experience using locking technology for complete wrist arthrodesis in patients with a reduced wrist size due to their stature and also for those who have a painful PWF or PRC, for whom the wrist fusion plate should be shorter.

Surgical Procedure

The downsized plates' appearance is similar to that of the AO standard curved plate. It was designed by the author, manufactured by Synthes (Oberdorf, Switzerland), and specially produced as a custom-made implant for the following types of patients: (1) patients with short stature and small hands; (2) patients with failed radioscapholunate (RSL) fusion or PRC, for whom a shorter plate is needed because only the mid-carpal or the radiocapitate joints have to be fused, respectively; and (3) patients with short stature and small hands following a failed PWF or PRC. The implant is made of titanium alloy and has two segments with undercuts to minimize contact with the underlying bones. The proximal segment is fixed to the distal quarter of the radius, and the distal segment is fixed to the third metacarpal. The implant has a palmarward curvature to fit over the carpal bones (►**Fig. 2**). Its total length is 94.0 mm, with a maximum thickness at the curved zone of 2.5 mm, and a proximal end width of 8.1 mm. Just at the distal part of the curved area, the plate extends 10° and narrows progressively by 6.0 mm at its distal end. To minimize overlying soft tissue irritation (extensor muscle, tendons, and skin), the plate has a smooth surface and both ends are rounded and tapered. The implant has three holes for radius fixation for 2.7- mm locking screws. It is fixed to the third metacarpal by means of three 2.4-mm locking screws. To increase the stability of the construct, another 2.4-mm locking screw can be inserted to stabilize the capitate. To reduce the plate length, rounded locking coaxial holes instead of combined locking–compression oblong holes were used; on the other hand, because of the central plate's curvature, axial compression is not feasible. ►**Table 1** compares the features of the standard plate with those of this implant.

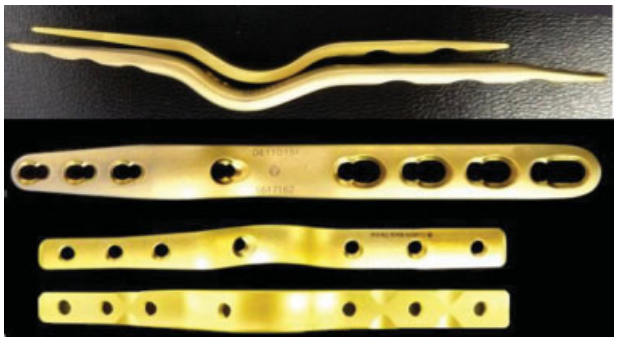

Fig. 2 Lateral (above) and frontal (below) views of the small custom-made curved plate and the standard TWF plate. The former is 20% shorter than the standard one. It is also thinner and narrower.

Table 1 Main features of the standard and the small curved TWF plates; total length of the small plate is 23.5 mm shorter than the standard plate; measurements are expressed in mm

	Standard plate	Small, curved plate
Material	Titanium alloy	Titanium alloy
Total length	117.5	94.0
Maximum thickness	3.6	2.5
Distal end width	8.0	6.0
Proximal end width	11.0	8.1
Radius screws	3.5 locking–compression	2.7 locking
Capitate-metacarpal screws	2.7 locking–compression	2.4 locking

Source: Synthes, Oberdorf, Switzerland.

Guidelines for the procedure do not differ from those used to implant the standard plate. A longitudinal straight skin incision is made. When present, previous scar incisions are used. A longitudinal capsular approach is made to reach the carpus. In those cases with a previous PWF, any existing hardware should be removed. The articular surfaces of the joints to be fused are first decorticated, and the sclerotic and dense subchondral bone is removed down to bleeding cancellous bone. Complete excision of the cartilage, the subchondral bone, or both down to healthy cancellous bone is crucial to allow bone ingrowth and subsequent bone healing at the fusion site. Once the alignment is achieved, a cancellous bone graft from the distal radius (the Lister tubercle and radial styloid), or from the distal ulna when a Darrach procedure has been performed, are interposed in those joints to be fused. To increase the fusion block at the proximal carpal row, in one wrist (Case 4) the author used one 2.4-mm compression screw as a lag screw between the scaphoid and the capitate. The author routinely uses this technique when a gap is noticed between two bones from the proximal row. In the present case, proximal pole necrosis and reabsorption did not allow good contact between the scaphoid and the lunate. Once the plate is placed and fitted in the wrist, the screws are inserted using a specific drill sleeve to lock their head within the plate's holes. Screw tightening is performed using a screwdriver with a torque limiter. The screw head is flush with the plate surface. The dorsal wrist capsule is closed over a suction drain, and the extensor pollicis longus tendon is rerouted subcutaneously overlaying the dorsal retinaculum.

The wrist is splinted after the surgery with plaster of Paris for 2 weeks, and then a removable, protective splint is employed until a radiologic solid union is observed. Forearm rotation is encouraged after the second follow-up visit at 2 weeks, except in Case 3, in which distal and proximal radioulnar joint fusions were performed (one-bone forearm). In this patient the wrist and elbow were splinted for 8 weeks, and for another 4 weeks a functional forearm brace was used to avoid pronation and supination. The follow-up protocol for all patients was at 6 weeks, every 2.5 or 3 months during the first year, and then every 6 months until the second year from the index procedure. In addition to clinical examination concerning finger motion and pronation/supination, plain X-ray images were taken during every visit to analyze the progression of bone healing. Physical and occupational therapy was started between the second and fourth weeks to improve the upper extremity function after the wrist fusion.

Patients and Methods

From May 2011 to April 2013, the author performed 19 TWFs using a specific wrist fusion plate, 13 of them with the small plate described in this article. There were 11 women and 2 men, aged from 20 to 76 years (mean: 48 years). The mean stature of 12 patients was 157 cm (minimum: 143 cm, maximum: 165 cm). One of the patients was 170 cm tall, and her wrist was fused due to a failed RSL fusion. Five of these wrists (four women and one man) fused by means of a curved plate had a follow-up longer than 1 year (mean:

Table 2 Baseline characteristics of the series

Patient #	Age/gender	Stature (cm)	Diagnosis	Previous surgeries	Date of surgery	Type of plate	Associated procedures
1	27 / F	170	DR fracture in childhood	RSL fusion and other procedures	May 2011	Curved	Hardware removal
2	47 / F	158	Rheumatoid arthritis	RSL fusion and ulna shortening	May 2011	Curved	Trapezium-trapezoid fusion
3	41 / F	154	Congenital disorder	Multiple procedures	June 2011	Curved	One-bone forearm
4	52 / M	156	SNAC wrist	—	February 2012	Curved	—
5	56 / F	154	DR fracture sequelae	RSL fusion	April 2012	Curved	Hardware removal

Abbreviations: DR, Distal radius; RSL, Radioscapholunate; SNAC, scaphoid nonunion advanced collapse.

19 months; maximum: 23 months) and are therefore described in this article. Age, gender, stature, and previous and associated surgical procedures to the index procedure are described in ►**Table 2**. In three of them the author had performed an RSL fusion with distal scaphoid excision 3, 5 and 10 years earlier than the TWF using either headed or headless cannulated compression screws.[7] One them had rheumatoid arthritis (Case 2), and the other two (Cases 1 and 5) were operated on for the sequelae of an intra-articular distal radius fracture. These three patients had an osteoarthritic midcarpal joint, with severe limiting pain and restriction of their daily living activities. In these patients the midcarpal and the carpometacarpal joint of the middle finger were fused. ►**Fig. 3a–c** describes Case 2.

Another patient had a developmental frontal plane malalignment of the distal radius (Case 3).[8] This patient had undergone a Sauvé-Kapandji procedure with subsequent painful proximal ulna stump, a distal ulna prosthesis to address the unstable ulna stump, prosthesis removal due to pain, radius shaft stress fracture and further plate fixation, and De Quervain disease release. The patient was very limited in her activities of daily life, with an unbearable pain at the wrist and forearm due to the painful, unstable ulna stump. Range of motion (ROM) of the wrist was very restricted and painful. The X-ray images showed a carpal collapse in association with flattening of the proximal pole of the scaphoid and the lunate. Both radiocarpal and midcarpal joints exhibited narrowing. A one-bone forearm was constructed in the same surgical procedure, interposing a block of iliac crest bone graft between the distal ulna stump and the radius. Distal and proximal radioulnar joints were fused using headless cannulated compression screws (►**Fig. 4a, b**). Case 4 had a very limited and painful wrist motion due to an advanced SNAC III wrist and was operated primarily (►**Fig. 5a, b**). In these two cases the radiocarpal, midcarpal, and capitate–metacarpal joints were fused.

Results

In all cases, bone–plate width and length ratios were optimal over the radius, the carpus, and the third metacarpal. The distal plate branch covered only the proximal half of the third metacarpal and was therefore distant from the metacarpophalangeal joint of the middle finger. Purchase of the screws in the underlying bones was excellent, providing a solid construct to allow an early hand therapy program for digital motion and forearm rotation. Capsular closure was performed easily, and there was enough soft tissue to cover the plate along its length. Early follow-up was fine in all patients, and they recovered a full digital flexion-extension arch earlier than 8 weeks, as well as forearm rotation, except in Case 3 (one-bone forearm case). There were neither early nor late postoperative complications such as wound breakage, persistent edema, infection, or carpal tunnel syndrome after the surgery. The fusions healed (bony bridges crossing the fusion sites) between 11 and 14 weeks after the surgery (mean: 13.2 weeks). At a mean of 5.3 months all fused articulations achieved bone remodeling. Alignment and length of the construct were maintained along the follow-up, and no screw loosening and toggling was noticed in any case. None of the implants have been removed.

The patients had no discomfort on the plates' ends and on the dorsum of the wrist. All of them (except Case 3) performed their activities of daily living, with minor restrictions, without pain at about 6 months. Even the patient of Case 3 was completely pain-free at both the wrist and the forearm

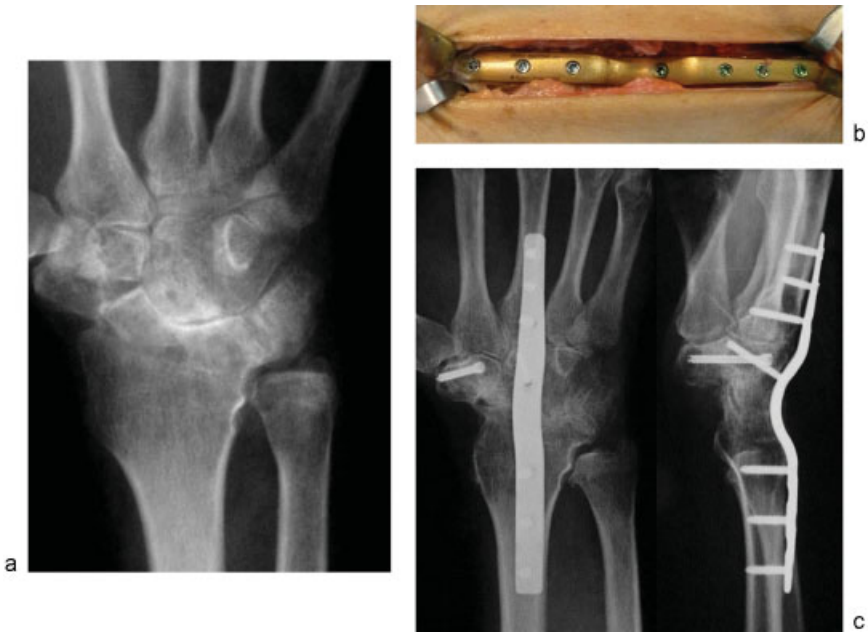

Fig. 3a–c Case 2. (**a**) Preoperative X-ray image showing the degenerative changes at the midcarpal joint. The distal radioulnar join remains mobile and painless after 10 years of an ulna shortening. (**b**) Intraoperative view once the plate has been fixed. The hand is on the right side. All the screws are locked to the plate in round, coaxial holes. (**c**) Radiological appearance of the fused wrist after 20 months of the index procedure. Plate fitting is excellent on the recipient bones. Size matching is much better than if a standard plate had been used.

Fig. 4a,b Case 3. (**a**) Radiocarpal and midcarpal collapse and narrowing can be seen. Scapholunate dissociation is also present. Distal ulna resection after the removal of the distal ulna prosthesis. (**b**) Wrist fusion is fully remodeled after 16 months of the surgery. Notice that the distal branch of the plate covers only the proximal half of the third metacarpal. Matching between the plate and the recipient bones is satisfactory. The iliac crest bone graft is also healed between the distal ulna stump and the radius ("one-bone forearm").

since the twelfth month after surgery. All five patients were satisfied with the result, and all of them expressed the opinion that the operation had fulfilled their preoperative expectations of the procedure.

Discussion

Complete wrist arthrodesis still remains a useful operation to address those wrist problems for which no motion-preserving procedures are feasible. Trauma, bone necrosis, and degenerative and inflammatory conditions about the wrist sometimes have to be managed by a TWF.[1–6] In the authors' experience of 126 fusions using plates since 1995, 56 of them were in women, affected mainly by inflammatory diseases but also by degenerative or posttraumatic arthritis. Fifty-three of these women needed a smaller implant to fit their wrists, either the aforementioned maxillofacial plate used during more than 10 years by the author (42 cases)[6] or the current custom-made plate now employed (11 cases). In many cases the standard implants are too large for certain patients and wrist conditions, as Orbay et al recently suggested.[9]

In the author's series of 13 consecutive cases using this downsized plate, the mean stature of 12 of patients was 157 cm. Synthes also does manufacture a downsized TWF plate which is available in the United States (Synthes, Paoli, PA, USA). However, that plate does not have locking fixation technology. Locking technology is desirable in patients with poor bone stock and osteopenia (rheumatoid arthritis and elderly persons) due to the risk of loosening and toggling of the screws. Suboptimal bone purchase can also occur in nonosteoporotic patients.[10,11] A shorter plate is also needed when a total fusion is indicated after a failed PRC or PWF. In these cases only the pseudoarthrotic joint (radiocarpal in PRC,

Fig. 5a,b Case 4. (**a**) Carpal advanced collapse secondary to a long lasting proximal pole nonunion and necrosis (SNAC wrist) in a 156 cm tall man. (**b**) Posteroanterior (PA) and lateral X-ray images at 1 year. The fusion is achieved and bone remodeling is noticed. To promote fusion between the scaphoid and the lunate, a lag screw was used to reduce the gap secondary to the disintegration of the proximal pole of the scaphoid. Cancellous bone graft from the radial styloid was also used. A standard plate would have been too large.

midcarpal in PWF) needs to be fused. In a recent article about TWF with concomitant removal of the proximal carpal row, Green and Henderson[12] noticed an intrinsic contracture of the middle finger that required release in 12 of their patients. This can occur because the distal branch of the plate was placed too close to the MP joint secondary to the axial bone shortening. This deleterious effect can be even more evident when the capitate is seated into a cavity in the distal radius. Using a shorter plate this potential issue can be avoided in those wrists fused after a failed PRC or an intentional resection of the proximal carpal row bones. In our series we did not have any case with stiffness at the metacarpophalangeal joint of the middle finger because the plates' distal end did not surpass the middle third of that metacarpal.

The implant described in this article provides a good fit with small-sized wrists as well as excellent bone purchase due to its locking technology. Despite its reduced length, width, and thickness, after a minimum follow-up of 1 year, none of the implants failed and all five wrists fused adequately in this patient population.

Note
Presented as a preliminary technical report at the 27th Annual Meeting of the International Wrist Investigator Workshop (IWIW). Las Vegas (NV), USA, September 7, 2011.

Conflict of Interest
None

References

1 Houshian S, Schrøder HA. Wrist arthrodesis with the AO titanium wrist fusion plate: a consecutive series of 42 cases. J Hand Surg Br 2001;26(4):355–359
2 Kalb K, Prommersberger KJ. Total wrist fusion using the AO wrist fusion plate [in German]. Oper Orthop Traumatol 2009;21(4-5):498–509
3 Solem H, Berg NJ, Finsen V. Long term results of arthrodesis of the wrist: a 6-15 year follow up of 35 patients. Scand J Plast Reconstr Surg Hand Surg 2006;40(3):175–178
4 Cavaliere CM, Chung KC. A systematic review of total wrist arthroplasty compared with total wrist arthrodesis for rheumatoid arthritis. Plast Reconstr Surg 2008;122(3):813–825
5 Nagy L, Büchler U. AO-wrist arthrodesis: with and without arthrodesis of the third carpometacarpal joint. J Hand Surg Am 2002;27(6):940–947
6 González del Pino J. Total wrist fusion in rheumatoid arthritis. A new perspective on plate fixation. In: Herren DB, Nagy L, Campbell DA, eds. Osteosynthesis in the Hand. Basel, Switzerland: Karger; 2008:99–106
7 Biswas D, Wysocki RW, Cohen MS, Fernandez JJ. Radioscapholunate arthrodesis with compression screws and local autograft. J Hand Surg Am 2013;38(4):788–794
8 Fernández DL, Capo JT, González E. Corrective osteotomy for symptomatic increased ulnar tilt of the distal end of the radius. J Hand Surg Am 2001;26(4):722–732
9 Orbay J, Feliciano R, Orbay C. Locked intramedullary total wrist arthrodesis. J Wrist Surg 2012;1(2):179–184
10 van Lenthe GH, Mueller TL, Wirth AJ, Müller R. Quantification of bone structural parameters and mechanical competence at the distal radius. J Orthop Trauma 2008; 22(8, Suppl):S66–S72
11 Ruchelsman DE, Mudgal CS, Jupiter JB. The role of locking technology in the hand. Hand Clin 2010;26(3):307–319, v
12 Green DP, Henderson CJ. Modified AO arthrodesis of the wrist (with proximal row carpectomy). J Hand Surg Am 2013;38(2):388–391